Gender differences in the impact of adolescent smoking on lung function and respiratory symptoms. The Nord-Trøndelag Health Study, Norway, 1995–1997

T. L. HOLMEN*, E. BARRETT-CONNOR†, J. CLAUSEN‡, A. LANGHAMMER*, J. HOLMEN* AND L. BJERMER§

*HUNT Research Center, Department of Community Medicine and General Practice, Faculty of Medicine, Norwegian University of Science and Technology, Trondheim, Norway, †Department of Family and Preventive Medicine, University of California, San Diego, U.S.A., ‡Department of Medicine, University of California, San Diego, U.S.A. and §Department of Lung Medicine, Norwegian University of Science and Technology, Trondheim, Norway

Abstract Girls take up smoking at least as frequently as boys. Few studies have focused on gender differences in the impact of adolescent smoking. We evaluated the sex-specific effect of adolescent smoking on respiratory symptoms and lung function. All students in junior high and high schools in Nord-Trøndelag County, Norway, 1995–97, were invited to participate in a cross-sectional study. Information on smoking habits and respiratory symptoms was obtained by self-administered questionnaires. Spirometry was performed in accordance with ATS standards. Eight-thousand-three-hundred and five students (83%) completed both questionnaire and spirometry. Among 6811 students aged 13–18 years (50.3% girls) with no history of asthma, 2993 (43.9%) reported never smoking, 665 (9.8%) reported occasional smoking, and 667 (9.9%) reported daily smoking (mean initiation age: 13.9 years). More boys than girls were heavy smokers. In all smoking categories, smokers reported a higher prevalence of respiratory symptoms than nonsmokers; symptoms increased with smoke burden. Girls reported more symptoms compared to boys with comparable smoke burden. A dose–response relation between smoking and reduced lung function was found only in girls. Girls were more vulnerable than boys to the impact of smoking on respiratory symptoms and lung function.

doi:10.1053/rmed.2002.1350, available online at http://www.idealibrary.com on IDEAL®

Keywords adolescents; cigarette smoking; gender difference; lung function; respiratory symptoms; epidemiology.

INTRODUCTION

Cross-sectional studies of adults show lower levels of lung function in cigarette smokers compared to never smokers (1). Longitudinal studies indicate that smoking speeds age-related decline in lung function and has dose-related effects (1–3). Cross-sectional and longitudinal studies among children and adolescents also show that smoking adversely affects lung function (2,4–7). Respiratory symptoms are reported to be increased in smokers (4–8), and presence of wheeze in smokers may lead to a higher risk for low levels of lung function (9).

Received 2 January 2002, accepted in revised form 28 January 2002.
Correspondence should be addressed to: Turid Lingaas Holmen, MD, PhD, HUNT Research Center, DMF, NTNU, Neptunveien 1, 7650 Verdal, Norway. Fax:+47 74 07 51 81;
E-mail: turid.lingaas.holmen@medisin.ntnu.no

Studies of gender differences in adults show inconsistent results; several studies suggest that smoking has a greater impact on lung function in men (10–12), whereas others report a more adverse effect in women (13–15). This difference may reflect gender differences in smoking habits in the populations (15), different reporting, or smoking may affect male and female lungs differently (16). Higher rates of wheeze and hyperresponsiveness in smoking women compared to men have been attributed, partly, to smaller airway caliber and smaller lung volume in women (5,17), with a disproportionately high dose of tobacco deposited in women than in men. Also, hormones may alter response in women (16). Tracheal epithelial response to cigarette smoke has been related to the estrous cycle (18,19).

The prevalence of adolescent smoking has been increasing. In many countries, girls smoke more frequently

or at least as frequently as boys (20,21). In one of the few studies that focused on gender differences in respiratory symptoms and lung function in smoking adolescents, Gold and colleagues (5) found cigarette smoking to be associated with mild airway obstruction and slowed growth of lung function in both sexes, but suggested that girls may be more vulnerable than boys to the effect of smoking on the growth of lung function. If girls are more vulnerable to effects of smoking, this would have major health implications.

The aim of this study was to examine gender-specific effects of smoking and smoke burden on respiratory symptoms and lung function in an adolescent population.

MATERIAL AND METHODS

From August 1995 to June 1997, a large health survey, the Nord-Trøndelag Health Study (HUNT), was conducted in Nord-Trøndelag County, Norway. All students in junior high schools (aged 13–16 years) and high schools (aged 16–19 years) in the county were invited to the youth part of the study, YOUNG-HUNT. A self-administered questionnaire was completed during one school hour, in a setting in which participants had no opportunity to look at other's papers. The questionnaire had no name or registration number, and was identifiable only by a bar code of the 11-digit personal number with which all Norwegians are registered at birth. Each student put the completed questionnaire in a blank envelope and sealed it. Project nurses collected the envelopes.

Questions and dichotomization used in this report are shown in the Appendix. Questions on respiratory symptoms were those used in the International Study of Asthma and Allergy in Childhood (ISAAC) (22). Current smokers were defined as those who answered "yes" to ever having tried smoking at least one cigarette and in addition answered "yes, I smoke daily" or "yes, I smoke occasionally, but not daily" to the question: "Do you smoke now?" (Appendix). Smokers were compared to those who answered "no" to ever having tried smoking. "Pack years" was defined as number of years of daily smoking multiplied by number of cigarettes smoked daily divided by 20, and grouped as follows: "Never smokers": those who had never tried smoking; "Light smokers": pack years >0, but <1; "Medium smokers": 1 pack year or greater, but <2; "Heavy smokers": 2 pack years or greater. Thirty self-reported daily smokers who did not report years of smoking were excluded. Passive smoking was defined as exposure to smoking at home by parents or siblings.

A clinical examination that included spirometry and height and weight was performed within a month after completion of the questionnaire. Spirometry was performed by specially trained nurses, in accordance with American Thoracic Society (ATS) standards (23), using computerized pneumotachographs (Jaeger Masterscope, software version 4.15, Jaeger Inc., Wurtzberg, Germany). The acceptability of spirometry results was assessed both during the testing and during the data analysis, and included review of the computerized ATS error codes reported from the Masterscopes as well as visual inspection of volume/time and flow/volume graphics. Achieving end-of-test acceptability was confirmed either from the computerized ATS error code regarding flow plateaus or from visual inspection of spirometry displays during testing.

Forced vital capacity (FVC), forced expiratory volume in 1 s (FEV_1), mid-forced expiratory flow (FEF_{50}), and FEV_1 percent in relation to the maximal FVC (FEV_1%FVC) were registered. FVC was defined as the largest of either forced expiratory or forced inspiratory vital capacity from technically acceptable curves. The reported FEV_1 was the largest value from technically acceptable curves. Standing height without shoes was measured using the standardized meter measures.

Ethics

Each student signed a written consent to participate in the study. Parents of students who were <16 years of age also gave written consent. The Regional Medicine Ethical Research Committee and the Norwegian Data Inspectorate Board approved the study.

Statistics

Students who reported ever having had asthma were excluded from these analyses. Girls and boys were analyzed separately. Comparisons between age at onset of smoking and mean pack years were made using independent sample t-tests. For symptoms, comparisons were performed using logistic regression adjusted for age, exposure to passive smoking, and smoking groups. Significance of gender differences was tested adding sex and smoking interaction to the models.

Lung function was analyzed using linear regression models with FVC, FEV_1, FEF_{50}, and FEV_1%FVC as dependent variables. Owing to heteroscedasticity, logarithmic (ln) transformation of lung function (Y) was used to fit model assumptions. Analyses of variance were used for comparisons between mean values of lung function measures in different smoking categories. In both regression analysis and analysis of variance separate models, stratified by sex, were made for daily smoking, occasional smoking, and different groups of pack years, adjusted for age, standing height, weight, passive smoking, physical activity, rhinitis, and acute bronchitis with cough. Estimates and 95% confidence intervals are ex-

pressed as percent differences, calculated from the logarithmic scale, with those who had never tried smoking as reference.

SPSS Base 8.0 for Windows (SPSS Inc, IL, U.S.A.) was used for all analyses.

RESULTS

Ninety-two percent of all students aged 13–19 years answered the questionnaire, and 8305 (83%) also completed spirometry. Included in these analyses were 6811 students aged 13–18 years (50.3% girls) who reported never having had asthma (Table 1). Of this number 2993 (43.9%) reported never having tried smoking, 665 (9.8%) reported occasional smoking, and 677 (9.9%) reported daily smoking (Table 2). Both daily and occasional smoking increased with age ($P < 0.001$). Mean age of smoking initiation was 13.9 years in both boys and girls for daily smokers, but was significantly higher in occasional smokers, 14.3 years for boys ($P=0.002$) and 14.4 years for girls ($P < 0.001$). Among daily smokers, mean years of daily smoking were 2.3 years in boys and 2.5 years in girls. On average, boys smoked more cigarettes daily (9.8 cigarettes) than girls (7.9 cigarettes) ($P < 0.001$). There was no significant difference between overall mean pack years for boys (0.24) compared to girls (0.21) ($P=0.21$), but in the heavy smoking group (2 pack years or more), boys had more mean pack years (3.4) than girls (2.7) ($P=0.001$).

Symptoms

Compared to never smokers, more smokers reported recent (past 12 months) wheeze or dry cough at night in the absence of respiratory infection (Table 3). Among smokers with comparable smoke burden and among never smokers, girls reported more respiratory symptoms than boys ($P < 0.001$ for all groups except pack years

Table 1. Age and sex distribution of students, aged 13–18 years, who reported never having asthma, had acceptable flow-volume curves, and participated both in the questionnaire and the lung function test in the YOUNG-HUNT study

	Boys	Girls	Total
Years	*n* (%)	*n* (%)	*n* (%)
13	553 (16.3)	552 (16.1)	1105 (16.2)
14	646 (19.1)	663 (19.3)	1309 (19.2)
15	639 (18.9)	671 (19.6)	1310 (19.2)
16	569 (16.8)	569 (16.6)	1138 (16.7)
17	544 (16.1)	507 (14.8)	1051 (15.4)
18	432 (12.8)	465 (13.6)	897 (13.2)
Total	3383 (49.7)[a]	3427 (50.3)[a]	6811 (100.0)

[a]Percent of all.

Table 2. Smoking status in adolescents, 13-18 years, participating in the YOUNG-HUNT study with both self-reported questionnaire and spirometry with acceptable curves. Adolescents who ever had asthma were excluded

	Age 13–15 Years		Age 16–18 Years		
	Boys *n* (%)	Girls *n* (%)	Boys *n* (%)	Girls *n* (%)	Total *n* (%)
Never tried smoking, not even one cigarette	979 (53.3)	964 (51.1)	543 (35.1)	507 (32.9)	2993 (43.9)
Tried smoking, but reported to be nonsmokers	438 (23.9)	459 (24.3)	490 (31.7)	439 (28.5)	1827 (26.8)
Previous smokers	109 (5.9)	131 (6.9)	90 (5.8)	107 (6.9)	437 (6.4)
Occasional smokers	114 (6.2)	182 (9.7)	168 (10.9)	201 (13.0)	665 (9.8)
Daily smokers	113 (6.1)	100 (5.3)	207 (13.4)	257 (16.7)	677 (9.9)
Missing data	84 (4.6)	50 (2.7)	48 (3.1)	30 (1.9)	212 (3.1)
Total	1838 (100.0)	1886 (100.0)	1546 (100.0)	1541 (100.0)	6811 (100.0)

Table 3 Wheeze or night cough (in the absence of respiratory infection) in the last 12 months by smoking pattern in adolescents included in the lung function study, adjusted for age and passive smoking and compared to those who had never tried smoking

	Never tried smoking	Occasional smokers			Daily smokers								
					Pack years >0<1			Pack years ⩾1 <2			Pack years ⩾2		
	n (%)[a]	*n* (%)[a]	OR(CI)	*P*	*n* (%)[a]	OR(CI)	*P*	*n* (%)[a]	OR(CI)	*P*	*n* (%)[a]	OR(CI)	*P*
Boys													
Wheeze	182 (13.4)	48 (19.4)	1.5 (1.0–2.1)	0.03	44 (35.5)	3.3 (2.2–5.1)	<0.001	31 (49.2)	5.8 (3.4–10.0)	<0.001	35 (49.3)	5.7 (3.4–9.6)	<0.001
Cough	185 (12.4)	72 (25.9)	2.3 (1.6–3.1)	<0.001	46 (35.4)	3.5 (2.3–5.2)	<0.001	40 (52.6)	5.5 (3.4–9.1)	<0.001	32 (40.5)	3.9 (2.4–6.6)	<0.001
Girls													
Wheeze	235 (18.5)	111 (35.2)	2.2 (1.7–2.9)	<0.001	92 (56.4)	5.0 (3.5–7.2)	<0.001	49 (57.0)	4.8 (3.0–7.8)	<0.001	38 (70.4)	8.5 (4.5–16.1)	<0.001
Cough	250 (17.5)	119 (31.6)	2.0 (1.6–2.6)	<0.001	101 (54.6)	5.2 (3.7–7.2)	<0.001	51 (51.0)	5.2 (3.7–7.3)	<0.001	40 (71.4)	10.2 (5.5–19.1)	<0.001

[a]Percent of total number of boys and girls in the smoking category. Compared to wheeze, 25 more boys and 24 more girls answered the cough question. Odds ratio (OR), confidence interval (CI)

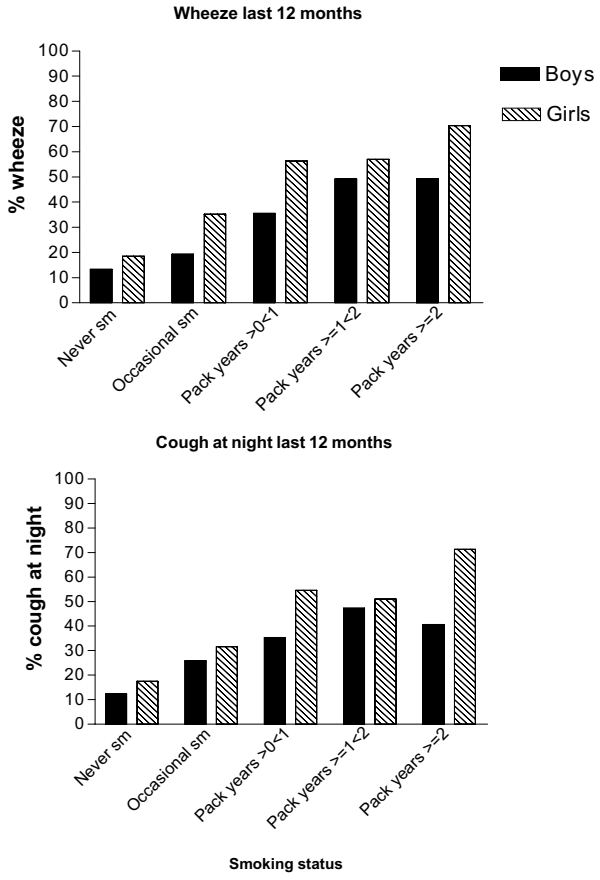

Fig. 1. Wheeze lasts 12 months and cough at night (without having a respiratory infection) lasts 12 months in adolescents by smoke burden compared to those who had never tried smoking. Those who reported ever having asthma were excluded.

1 or more, but <2) (Fig. 1). The finding of greater increase in symptoms with increasing smoke burden in girls than in boys was confirmed by a significant sex–pack years interaction ($P<0.001$) in the logistic regression model.

Lung function

Occasional smokers had significantly better FVC than those who had never tried smoking (Fig. 2); this was true in both boys ($P<0.001$, mean difference 180 ml) and girls ($P=0.04$, mean difference 62 ml). In similar comparisons, only boys had significantly larger FEV_1 ($P=0.002$, mean difference 105 ml); no significant differences were found for FEF_{50} or FEV_1%FVC in either boys or girls.

In daily smokers, a dose-response was found between smoking and levels of FEV_1, FEF_{50}, and FEV_1%FVC in girls, but not in boys (Fig. 2). Compared to never smokers, FEV_1 and FEF_{50} levels in girls were significantly lower only in heavy smokers (2 pack years or more) (mean difference 145 ml, $P=0.01$ and mean difference 399 ml, $P=0.002$, respectively), whereas levels of FEV_1%FVC were significantly lower for both medium smokers (1 pack year or more, but <2) and heavy smokers ($P=0.03$ and $P=0.001$). The largest reduction, found in heavy smokers, was 3.8%. Both daily smoking boys and girls had higher FVC than never smokers, but boys had higher FVC with a higher smoke burden than girls. For girls, this was significant only in light smokers (mean difference 120 ml, $P=0.002$), whereas in boys significantly higher levels of FVC were found in medium smokers (mean difference 213 ml, $P=0.003$) (Fig. 2). FVC decreased with increasing number of pack years in girls, but did not become significantly different from never smokers or from light smokers.

Although smoking adolescents were more likely than nonsmokers to have smoking family members, this source of passive smoking did not explain the gender differences (data not shown). Results were also not materially changed when analyses were repeated including the students with known asthma (data not shown). The effect of smoking on respiratory symptoms or lung function parameters did not differ in the 467 girls who used contraceptives compared to the girls who did not (data not shown).

DISCUSSION

In this large study of adolescents, with high participation rates and carefully supervised spirometry testing, girls were more vulnerable than boys to the effects of the same cigarette smoke burden on lung function and respiratory symptoms. The limitations of a causal interpretation of cross-sectional studies are well known, and the present study cannot address gender differences in lung growth or maximal attained lung function. But this study is important because very few studies have addressed the question of gender difference in susceptibility of the effects of cigarette smoke on lung function in adolescence, and this question is highly relevant in the light of increasing smoking prevalence in young girls.

Our findings of increasing wheeze and cough with increasing smoke burden agree with other studies (4,5,8). Rates of wheeze and cough were higher for girls than for boys in each level of smoking, concordant with the findings of Gold *et al*. (5). In the present study, girls who never smoked also reported more wheeze and cough than boys who had never smoked, but girls reported more frequent symptoms with regard to multiple other health problems, suggesting that girls perceive symptoms differently than boys or report them more readily (16). Nevertheless, the greater increase in symptoms per level of smoke burden in girls compared to boys suggests that girls really are more susceptible to changes in bronchial reactivity with smoking. In girls only, we found a dose–response relation between smoking and levels of

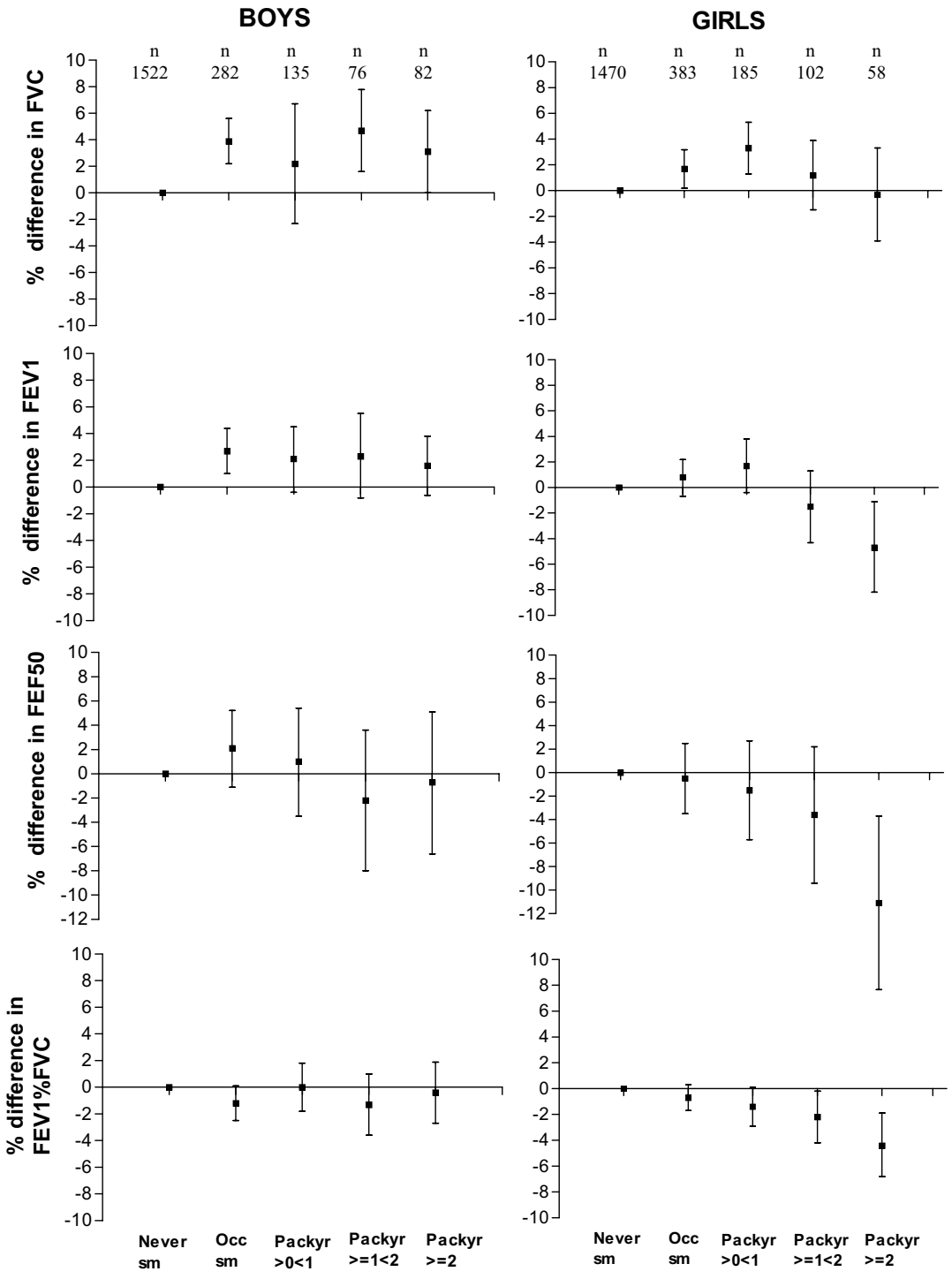

Fig. 2. Sex-specific effects of smoking on lung function in adolescents, 13–18 years; boys: $n = 2097$ and girls $n = 2198$. Percent differences and 95% confidence intervals for differences were calculated on a logarithmic scale using those who had never tried smoking as reference, and adjusting for age, height, weight, passive smoking at home, exercise, rhinitis and acute bronchitis with cough: "Never sm" denotes never having tried smoking, "Occ. sm": Occasional smokers, "Packyr $>0<1$": pack years between 0 and 1, "Packyr $\geq 1<2$": 1 pack year or more, but < 2, "Packyr ≥ 2": 2 pack years or more.

FEF_{50} and FEV_1%FVC, parameters typically associated with obstructive airway disease (5,24). This finding is in agreement with the greater increase in symptoms with increasing smoke burden in girls. The dose–response increase in symptoms seen in boys indicates that smoking has an early impact on respiratory function in boys too, and that symptoms precede changes in lung function, illustrating the potential importance of focusing on

current health problems in young smokers when encouraging smoking cessation (25). The observation of increased symptoms in both sexes, whereas physiological consequences measured as changes in lung function are seen in girls only, is consistent with a sex difference secondary to the lower airway caliber in girls compared to boys.

A carefully done longitudinal study by Gold *et al*. (5), suggested that girls might be more vulnerable than boys to the effect of smoking on the growth of lung function, but found no gender difference in the cross-sectional data, unlike the present study. Gold *et al*. (5) reported reduced FEF_{25-75} and FEV_1%FVC in both boys and girls with the highest level of smoke burden. Using the same measure of smoke burden (number of cigarettes per day, with 15 or more as highest level), and the same lung function parameters as Gold *et al*., in the present study, we still found the reduction in lung parameter only in girls and not in boys. The number of both boys and girls with the highest smoke burden (2 pack years or more), was smaller in our study than in the study by Gold *et al*., but the number of boys with the highest smoke burden in the present study was larger than the number of girls. Moreover, these boys had higher mean pack years compared to the girls.

As girls attain their maximal value of lung capacity at a lower age than boys (16), the older girls in this study may have had attained their maximal values of lung capacity, while the boys still were in a slow growth phase. The analyses in the present study were done sex-specific adjusting for age, height and weight, and it is unlikely that the difference in attained maximal lung capacity would affect the results. The observed lung function in adolescents may also be influenced by stage of maturation. Adding the self-reported stage of breast growth in girls and voice changing in boys to the regression models did not change the results (data not shown).

It has been postulated that the effect of smoking on respiratory symptoms or lung function is modulated by hormonal factors (16,18,19). Only 13% of girls in the present study were using oral contraceptives and no different effect of smoking on respiratory symptoms and lung function was observed in users compared to nonusers.

Lung capacity (FVC) was greater in light smokers compared to never smokers, concordant with the previous cross-sectional and longitudinal studies of young people (5,26). This suggests selection bias of adolescent smokers equivalent to "the healthy smokers effect", described in adult populations (15). This bias may explain the different impact of smoking on lung function seen in different cross-sectional studies of young people (4). It is not known whether such selection bias applies differently to boys and girls, but it is unlikely that gender differences in pulmonary function in heavy smokers are explained by a "healthy smoker" bias.

A correlation between smoking and the incidence of asthma and bronchial hyperreactivity has been reported, implying that girls, compared to boys, have an increased risk of bronchial hyperreactivity and of developing asthma if they smoke (17,27). To study the impact of smoking on respiratory symptoms and lung function we excluded the students reporting known asthma, the majority of whom reported having asthma before they started smoking. Including students with known asthma in the analyses did not change the results.

In spite of the computerized ATS error code warnings during testing, and careful assessment of the quality of the flow/volume curves by the nurses, a number of students did not meet the 1987 ATS criteria as judged by the ATS error code messages from the Jaeger Masterscope. As meeting the ATS criteria in adolescents have been reported to be difficult (23,28–30), and excluding any group not achieving ATS recommendation might have selectively excluded smokers (30), all students were included in the analysis. However, separate analyses excluding students with different ATS error codes registered in the Jaeger Masterscope did not significantly change the results (data not shown).

Self-reported smoking habits and respiratory symptoms were potentially subject to biased reporting. However, this anonymous study was designed to foster truthful reporting and self-reported smoking habits have been found to be reliable in young Norwegian men and women (31). Pack years was chosen as a measure of smoke burden for daily smokers because both duration (years with smoking) and intensity (number of cigarettes) of exposure are expected to affect lung function. Pack years could be biased by age when smoking began, but debut age did not affect lung function when substituted for pack years in the regression model (data not shown).

These data support the thesis that girls are more susceptible to the effects of smoking than boys. Since girls now smoke more or at least as frequently as boys, the possibility that they are more vulnerable to the effects of smoking suggests an increasing female burden of morbidity and mortality due to cigarette smoking. This plus the early average age of smoking initiation confirms the importance of early intervention for smoking prevention.

Acknowledgements

This study was supported by the Norwegian Research Council, the Norwegian State Department of Social and Health Affairs, the County of Nord-Trøndelag, Norway and ASTRA ZENECA AS. The authors gratefully acknowledge the contributions of Bitte Dillan, Grete Bratberg Ross, Aina Enes, Inger Duvsete Holbø and the project nurses.

REFERENCES

1. U.S. Department of Health and Human Services. Public Health Service, Center for Disease Control and Prevention, National Center for Chronic Disease Prevention an Health Promotion, Office of Smoking and Health. The health consequences of smoking: chronic obstructive lung disease. A report of the Surgeon General. DHHS Publication No. (PSH) 84-50205, 1984.
2. Jaakkola MS, Ernst P, Jaakkola JJ, N'gan'ga LW, Becklake MR. Effect of cigarette smoking on evolution of ventilatory lung function in young adults: an eight year longitudinal study. *Thorax* 1991; **46:** 907-913.
3. Tager IB, Segal MR, Speizer FE, Weiss ST. The natural history of forced expiratory volumes. Effect of cigarette smoking and respiratory symptoms. *Am Rev Respir Dis* 1988; **138:** 837-849.
4. U.S. Department of Health and Human Services. Public Health Service, Center for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office of Smoking and Health. Preventing tobacco use among young people. A Report of the Surgeon General, 1994.
5. Gold DR, Wang X, Wypij D, Speizer FE, Ware JH, Dockery DW. Effects of cigarette smoking on lung function in adolescent boys and girls. *N Engl J Med* 1996; **335:** 931-937.
6. Prokhorov AV, Emmons KM, Pallonen UE, Tsoh JY. Respiratory response to cigarette smoking among adolescent smokers: a pilot study. *Prev Med* 1996; **25:** 633-640.
7. Tager IB, Munoz A, Rosner B, Weiss ST, Carey V, Speizer FE. Effect of cigarette smoking on the pulmonary function of children and adolescents. *Am Rev Respir Dis* 1985; **131:** 752-759.
8. Lam TH, Chung SF, Betson CL, Wong CM, Hedley AJ. Respiratory symptoms due to active and passive smoking in junior secondary school students in Hong Kong. *Int J Epidemiol* 1998; **27:** 41-48.
9. Jaakkola MS, Jaakkola JJ, Ernst P, Becklake MR. Ventilatory lung function in young cigarette smokers: a study of susceptibility. *Eur Respir J* 1991; **4:** 643-650.
10. Camilli AE, Burrows B, Knudson RJ, Lyle SK, Lebowitz MD. Longitudinal changes in forced expiratory volume in one second in adults. Effects of smoking and smoking cessation. *Am Rev Respir Dis* 1987; **135:** 794-799.
11. Dockery DW, Speizer FE, Ferris BGJ, Ware JH, Louis TA, Spiro A. Cumulative and reversible effects of lifetime smoking on simple tests of lung function in adults. *Am Rev Respir Dis* 1988; **137:** 286-292.
12. Xu X, Dockery DW, Ware JH, Speizer FE, Ferris BGJ. Effects of cigarette smoking on rate of loss of pulmonary function in adults: a longitudinal assessment. *Am Rev Respir Dis* 1992; **146:** 1345-1348.
13. Langhammer A, Johnsen R, Holmen J, Gulsvik A, Bjermer L. Cigarette smoking gives more respiratory symptoms among women than among men. The Nord-Trondelag Health Study (HUNT). *J Epidemiol Community Health* 2000; **54:** 917-922.
14. Prescott E, Bjerg AM, Andersen PK, Lange P, Vestbo J. Gender difference in smoking effects on lung function and risk of hospitalization for COPD: results from a Danish longitudinal population study. *Eur Respir J* 1997; **10:** 822-827.
15. Xu X, Li B, Wang L. Gender difference in smoking effects on adult pulmonary function. *Eur Respir J* 1994; **7:** 477-483.
16. Becklake MR, Kauffmann F. Gender differences in airway behaviour over the human life span. *Thorax* 1999; **54:** 1119-1138.
17. Kanner RE, Connett JE, Altose MD, Buist AS, Lee WW, Tashkin DP, Wise RA. Gender difference in airway hyperresponsiveness in smokers with mild COPD. The Lung Health Study. *Am J Respir Crit Care Med* 1994; **150:** 956-961.
18. Chalon J, Loew DA, Orkin LR. Tracheobronchial cytologic changes during the menstrual cycle. *JAMA* 1971; **218:** 1928-1931.
19. Hayashi M, Sornberger GC, Huber GL. Differential response in the male and female tracheal epithelium following exposure to tobacco smoke. *Chest* 1978; **73:** 515-518.
20. Healton C, Messeri P, Reynolds J, Wolfe C, Stokes C, Ross J, Flint K, Robb W, Farrelly M. Tobacco use among middle and high school students—United States, 1999. *Morb Mortal Wkly Rep* 2000; **49:** 49-53.
21. King A, Wold B, Tudor-Smith C, Harel Y. The health of youth. A cross-national survey. *WHO Reg Publ Eur Ser* 1996; **69:** 1-222.
22. Asher MI, Keil U, Anderson HR, Beasley R, Crane J, Martinez F, Mitchell EA, Pearce N, Sibbald B, Stewart AW. International Study of Asthma and Allergies in Childhood (ISAAC): rationale and methods. *Eur Respir J* 1995; **8:** 483-491.
23. American Thoracic Society. Standardization of spirometry-1987 update. Statement of the American Thoracic Society. *Am Rev Respir Dis* 1987; **136:** 1285-1298.
24. Wright JL, Cagle P, Churg A, Colby TV, Myers J. Diseases of the small airways. *Am Rev Respir Dis* 1992; **146:** 240-262.
25. Holmen TL, Barrett-Connor E, Holmen J, Bjermer L. Health problems in teenage daily smokers versus nonsmokers, Norway, 1995-1997: the Nord-Trondelag Health Study. *Am J Epidemiol* 2000; **151:** 148-155.
26. Tashkin DP, Clark VA, Coulson AH, Bourque LB, Simmons M, Reems C, Detels R, Rokaw S. Comparison of lung function in young nonsmokers and smokers before and after initiation of the smoking habit. A prospective study. *Am Rev Respir Dis* 1983; **128:** 12-16.
27. Larsson L. Incidence of asthma in Swedish teenagers: relation to sex and smoking habits. *Thorax* 1995; **50:** 260-264.
28. Hankinson JL, Bang KM. Acceptability and reproducibility criteria of the American Thoracic Society as observed in a sample of the general population. *Am Rev Respir Dis* 1991; **143:** 516-521.
29. American Thoracic Society. Standardization of spirometry, 1994 update. *Am J Respir Crit Care Med* 1995; **152:** 1107-1136.
30. Ng'ang'a LW, Ernst P, Jaakkola MS, Gerardi G, Hanley JH, Becklake MR. Spirometric lung function. Distribution and determinants of test failure in a young adult population. *Am Rev Respir Dis* 1992; **145:** 48-52.
31. Foss OP, Haug K, Hesla PE, Lund-Larsen PG, Vasli LR. [Can we rely on self-reported smoking habits?]. *Tidsskr Nor Laegeforen* 1998; **118:** 2165-2168.

APPENDIX A

Questions and alternative answers used in the study. are given in Table AI.

Table AI

Questions	Possible answers				
Haves you ever tried smoking (at least one cigarette)?	Yes	No			
If yes, do you smoke?	Yes, I smoke —cigarettes daily	Yes, I smoke occasionally, but not daily	No, previously I smoked daily	No, previously I smoked occasionally	No, I don't smoke
How old were you when you started smoking?	—Age				
How many years all together have you been smoking daily?	— Number of years				
Does anyone in your home smoke?[a]	No	Yes, mother	Yes, father	Yes, siblings	
During the last 12 months, have you had problems with sneezing and/or a clogged or runny nose when you do NOT have a cold or the flu?	Yes	No			
During the last 12 months; have you had wheeze or heavy breathing?	Yes	No			
During the last 12 months; have you had dry cough at night without having a cold or the flu?	Yes	No			
Do you have a cold with cough or bronchitis today?	Yes	No			
Outside school hours How many days a week do you play sports, or exercise to the point where you breathe heavily and/or sweat?	Every day	4–6 days	2–3 day I days every 14 days	Every month	Less/never

[a]The answer is dichotomized into: on one smokes (no) and someone smokes (mother and/or father and/or siblings smoke).